

# Do somatic markers mediate decisions on the gambling task?

TO THE EDITOR—Recent work suggests that emotions are critical in mediating decisions<sup>1–3</sup>. A dominant perspective is the somatic marker hypothesis, which posits that emotional bodily responses (‘somatic markers’) can unconsciously bias decision-making<sup>1,4</sup>. This hypothesis was initially inspired by observations of decision-making deficits among patients with prefrontal damage<sup>4</sup>. The interpretation of these observations depended crucially on the performance of normals using a gambling task in which the accumulation of emotional responses biased decision making<sup>5–7</sup>. Here we provide an alternative explanation for the performance of normal subjects on the gambling task by

showing how factors other than somatic markers may alter decision making.

In the gambling task, a participant is presented with four decks of cards. After turning over a card, participants either win or lose varying amounts of play money. Unknown to the participants, picking from two of the decks (‘good’ decks) will result in eventual gain, whereas picking from the other two decks (‘bad’ decks) will result in eventual loss. The task ends after the selection of the 100<sup>th</sup> card, when most normal individuals have picked more cards from the good than the bad decks.

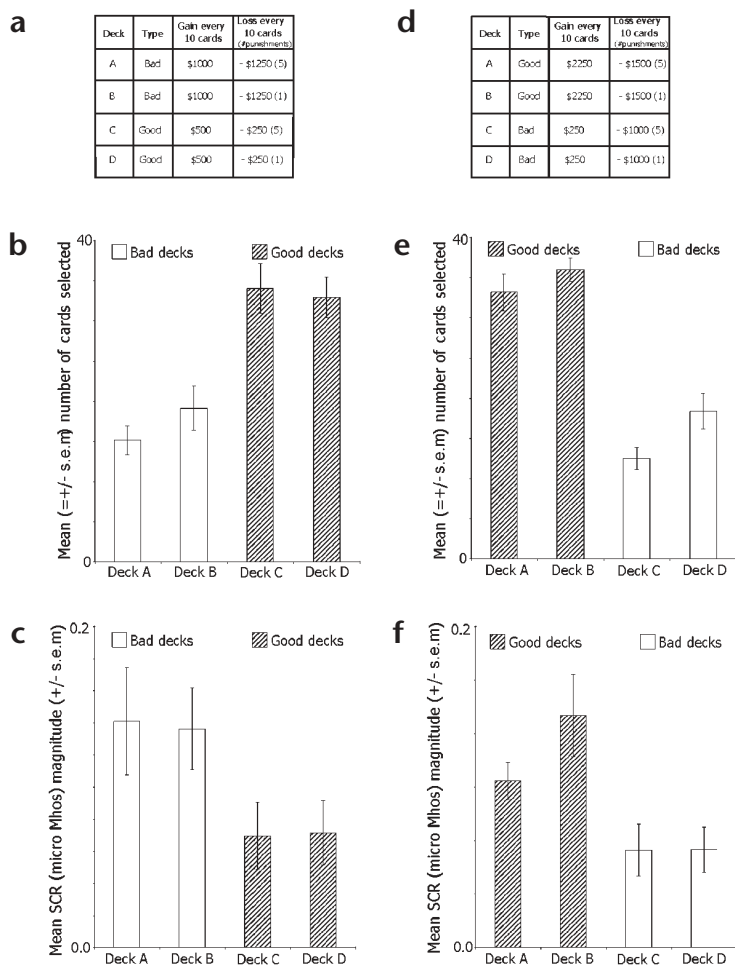
In previous studies of this task<sup>5,6</sup>, experimenters recorded skin conductance responses (SCRs) as a measure of bodily

state. After several rounds of picking cards, it was found that ‘anticipatory’ SCRs, recorded several seconds before each card selection, were significantly higher for the bad decks than for the good decks.

At least two hypotheses may account for this result. First, anticipatory SCRs may be correlates of correct versus incorrect decision making<sup>5,6</sup>. Thus, the larger anticipatory SCR magnitude for bad decks represents a cumulative bodily signal that biases participants against choosing from long-term bad decks. A second hypothesis lies in the reward and punishment schedule of the decks. Because the amount of money both gained and lost for each card (per ten cards) is much greater for bad than for good decks (Fig. 1a), participants’ anticipatory SCRs may have been higher for bad decks because they were expecting an immediate higher-magnitude decision.

We have tested these alternative explanations. Only the first hypothesis attributes to SCRs a role in learning and decision-making. In Experiment 1, we replicated the design and primary results of the original gambling task (Fig. 1a–c). Participants picked more cards from the good versus bad decks, and showed higher anticipatory SCRs for bad versus good decks.

In Experiment 2, we changed the card scheme such that good decks were associated with a higher magnitude of punishment and reward than bad decks. If somatic markers drive long-term good/bad evaluation of the decks, as predicted by the first hypothesis, then the magnitude of anticipatory SCRs should be higher for bad decks. If the alternative hypothesis is correct, then there should be higher SCRs for good decks. Results support the second hypothesis: participants picked more cards from good decks, and this selection was accompanied by higher



**Fig. 1.** Original and modified gambling tasks. In each experiment, subjects were five male and five female Harvard undergraduate students. (a) Card scheme for Experiment 1 (original task), in which bad decks had a higher magnitude of punishment and reward than good decks. (b) In Experiment 1, subjects chose more cards from good than bad decks ( $t_{38} = -6.47, P < 0.001$ ). (c) Anticipatory SCRs in Experiment 1 were higher for bad decks compared to good decks ( $t_{38} = 2.74, P < 0.01$ ). (d) Card scheme for Experiment 2 (modified task), in which good decks had a higher magnitude of punishment and reward than bad decks. (e) In Experiment 2, subjects chose more cards from good than bad decks ( $t_{38} = 9.67, P < 0.001$ ). (f) Anticipatory SCRs in Experiment 2 were higher for the good decks than for the bad decks ( $t_{38} = 3.57, P < 0.001$ ).

anticipatory SCRs for good decks than for bad decks (Fig. 1d–f).

Results suggest that across both experiments, card selection is driven by long-term consequences, whereas anticipatory SCRs are driven by the immediate act to be performed, independently of the positive or negative long-term value of the decision. In the original gambling task experiments<sup>5,6</sup>, anticipatory SCRs were interpreted as correlates of somatic markers that bias individuals' decision-making. However, by changing the schedule of punishments and rewards in Experiment 2, we observed an opposite pattern of SCRs. We conclude that SCRs in the standard version of the gambling task do not provide evidence for the role of somatic markers in decision making.

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REPLY—The authors report two studies. In one, they used the standard version of our gambling task and replicated our results. In the other, they used a new task, with a superficial resemblance to the original, but with substantial conceptual differences. They suggest that their results are not compatible with our interpretation of the original gambling task or with the somatic marker hypothesis. We welcome their question but disagree.

The task in their second experiment involves two decks of cards (A & B) for which both rewards and punishments are high, but in which the rewards always outweigh the punishments; playing from these decks offers both immediate and long-term gains. (A & B are 'good decks'.) Decks C & D have smaller rewards and punishments, but still the punishments are four times higher than the rewards; playing from these decks gives low immediate reward and long-term loss ('bad decks'). Compared to the original task, decks A & B are more readily recognizable as preferable (immediate reward is 10 times the value of that in C & D) and ultimately

advantageous. (Penalties never cancel the gain, as in decks C & D.) The immediate tendency to prefer the high reward does not need to be opposed in order to achieve. Apparent and ultimate goodness coincide. There is no conflict. Normal subjects should prefer decks A & B.

In the original task, the higher anticipatory SCRs preceded card turns from bad decks; by contrast, in the modified task, higher anticipatory SCRs preceded turns from good decks. Because higher anticipatory SCRs related to decks carrying the immediate higher magnitude of reward or punishment, the authors argue that "...anticipatory SCRs are driven by the immediate act to be performed" and are irrelevant to the final outcome. We agree that SCRs index a process driven by the immediate act to be performed, but this does not mean that anticipatory SCRs are unrelated to long-term decisions.

The authors believe that if somatic markers drive the evaluation of the goodness or badness of the decks, then higher anticipatory SCRs should precede picking from bad decks (decks C & D) in the modified task. They assume that somatic markers can only be negative and only precede options leading to a bad outcome. However, somatic markers can be either positive or negative, and under conflict and uncertainty they help reject or endorse an option of action. This suggests a possible interpretation of the authors' results, namely that their task inverts the marker signal. In the original task, the higher anticipatory SCRs relative to bad decks reflected a negative somatic state that promoted avoidance of bad options. In the modified task, higher anticipatory SCRs to good decks may reflect a positive somatic state that promotes approach. Our own work<sup>8,9</sup> with another modified gambling task that preserved conflict and uncertainty, but switched reward and punishment, revealed approach behavior coupled with high anticipatory SCRs. Also, patients with ventromedial prefrontal cortex lesions (which preclude the development of these anticipatory SCRs) performed disadvantageously on that modified task, just as they did on the original task. Although higher anticipatory SCRs probably relate to the magnitudes

of reward or punishment hidden in the deck from which subjects are about to select, depending on whether anticipatory SCRs reflect negative or positive somatic states, higher anticipatory SCRs also coincide with the long-term consequences—anticipation of a long-term negative or positive outcome. When anticipatory SCRs do not develop, a support mechanism for making advantageous decisions under conflict and uncertainty falls apart, as was critically demonstrated in patients with prefrontal damage<sup>6</sup>.

Another explanation for the finding would be that high-magnitude anticipatory SCRs before good decks reflect a non-conscious danger signal related to the likely risk of a large penalty. Given the modified task's design, such signals would not influence behavior because the conscious assessment of the overall goodness of the decks would prevail. Either interpretation is in accord with the somatic marker hypothesis. Somatic markers assist decision-making, covertly or overtly, but are not engaged in every decision, and their 'advice' need not be heeded. We caution against the idea that emotion-based signals 'decide' for us, other than in extreme situations.

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